Appendix

A. Statistical Methodology for Measuring the Impact of the Water Bank on Operating Costs and Crop Sales

We model the change in operating costs per acre in the farm operation between 1990 and 1991 as

$$dy_j^B = \alpha + X_j\beta + \varepsilon_j \ ,$$

where

$$dy_j^B = y_j^B - y_j^{90} \ .$$

y_j^B is farmer j's operating costs per acre in 1991, and y_j^{90} is the operating costs per acre in the farmer's 1990 operation. X_j is a $(1 \times K)$ vector of the acre-feet per acre in the operation sold to the Bank by not irrigating crop k $(k = 1 \ldots K)$ in 1991. ε_j is distributed i.i.d. normal. We interpret this equation as a reduced-form relation resulting from a farmer's decision to maximize profits given his or her Bank sales. We normalize by the number of acres in the farming operation to control for changes in the size of the farming operation between 1990 and 1991. We use operating costs in the overall operation and not just those on the land put in the Bank both because farmers usually can only give costs for their entire operation and because farmers may shift some inputs from Bank land to non-Bank land.

Had there been no Bank in 1991, X_j would be zero, and the change in operating costs per acre would have been

$$\begin{aligned} dy_j^N &= y_j^N - y_j^{90} \\ &= \alpha \ , \end{aligned}$$

where y_j^N is what operating costs per acre would have been in 1991 had there been no Bank.

We are interested in $y_j^B - y_j^N$, which is the difference between operating cost per acre in 1991 with the Bank and operating costs per acre in 1991 had there been no Bank.

$$\begin{aligned} y_j^B - y_j^N &= \left(dy_j^B + y_j^{90}\right) - \left(dy_j^N + y_j^{90}\right) \\ &= dy_j^B - dy_j^N \\ &= X_j\beta \ . \end{aligned}$$

Thus, the components of the vector β measure the impact of buying an acre-foot of water on operating costs for the K crops.

In the survey, farmers reported the number of acres of each crop they put into the Bank. We used farmer-specific data provided by DWR on the acre-feet generated by each crop put in the Bank to convert the acres to acre-feet of water sold to the Bank.

We estimated α and β using ordinary least squares. We used the same model to estimate the impact of the Bank on crop sales. Table A.1 reports estimates of both the operating cost and crop sales equations for NIL contacts.[1]

As discussed in the text, water bought through multiple-response contracts when no groundwater pumps are available is combined with water bought by fallowing rice through no-irrigation contracts. We tested whether the rice coefficients for the two types of contracts were different. The coefficient for multiple-response contracts was lower than the rice coefficient for no-irrigation contracts in both the operating cost and crop sales equations, but the difference was not statistically significant.

A measure of the profitability of putting each crop in the Bank can be derived by subtracting the operating cost coefficients from the crop sales coefficients in Table A.1 and adding the total to $125. With the exception of sugar beets, realized profits for each crop are positive. It appears that farmers would have done better growing sugar beets than putting them in the Bank. (This does not mean they actually lost money on the sugar beets they put in the Bank.) It is important to note that these are realized profits, not the expected profits at the time the decision was made to participate in the Bank. Also, when farmers decided to participate, they may have been willing to accept lower profits in return for the certainty of a Bank payment.

For GWEL contracts,[2] we have no breakdown by crop, so we only use total acre-feet sold to the Bank per acre in the farm operation. This means that X_j is a scalar for groundwater contracts. Table A.2 reports the estimates for GWEL

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[1]These are farmers with no-irrigation contracts and farmers in agencies with multiple-response contracts and no groundwater pumps.

[2]These include farmers with groundwater-exchange contracts and farmers in agencies with multiple-response contracts who had groundwater pumps.

Table A.1

Regression Analysis of Impact of Water Bank Sales on Operating Costs and Crop Sales for NIL Contracts

	Operating Costs		Crop Sales	
	Coeff.	Std. Error	Coeff.	Std. Error
Constant	–1.86[b]	15.15	16.53	43.08
Rice	–79.23[a]	28.62	–117.20	88.48
Sugar beets	–51.85[a]	14.20	–287.13[a]	38.43
Alfalfa	–48.46[a]	11.10	–155.74[a]	30.18
Wheat	–34.96[b]	18.89	–107.67[a]	52.02
Corn	–32.30[b]	17.34	–137.52[a]	47.33
Other	–29.82[b]	17.55	–142.94[a]	47.39
Pasture	0.24	9.95	–37.51	31.19
N	82		73	
Dep. Mean	–48.89		–176.41	
R-square	0.31		0.54	
RMSE	58.19		154.95	

[a]Significantly different from zero with 95-percent confidence.
[b]Significantly different from zero with 90-percent confidence.

Table A.2

Regression Analysis of Impact of Water Bank Sales on Operating Costs and Crop Sales for GWEL Contracts

	Operating Costs		Crop Sales	
	Coeff.	Std. Error	Coeff.	Std. Error
Constant	14.47[a]	7.87	61.04	71.82
AF sold per acre	–3.06	5.47	–92.32[b]	44.76
N	13		10	
Dep. mean	10.64		–76.30	
R-square	0.03		0.34	
RMSE	13.87		85.10	

[a]Significantly different from zero at 5-percent confidence.
[b]Significantly different from zero at 10-percent confidence.

contracts. Farmers who sold groundwater to the Bank mainly grew rice, so the slope coefficient is primarily a rice effect. We also tested to see if the effect for the observations from multiple response contracts were different. With only two multiple-response observations with groundwater pumps, it would be hard to find any differences. In any case, the estimate for multiple-response contracts was not much different from that for groundwater-exchange contracts, and the difference was not statistically significant.

Prediction of Impact of All Bank Sales

The impact of the Bank on the overall operating costs of farmer j is

$$\Delta_j = w_j X_j \beta \ ,$$

where w_j is the total acres in farmer j's 1991 operation. The combined impact for all farmers in the Bank is

$$\Delta = w' X \ \beta \ ,$$

where now w is an (N × 1) vector of acreage for each of the N participants in the Bank, and X is an (N × K) matrix of water sold to the Bank per acre by crop. We estimated the overall change in operating costs due to the Bank using

$$\hat{\Delta} = w' X \hat{\beta} \ ,$$

and the standard error of $\hat{\Delta}$ is

$$\hat{s}^2\left(\hat{\Delta}\right) = \tilde{w}' \ X\left(\tilde{X}' \ \tilde{X}\right)^{-1} X' \ \tilde{w} \ ,$$

where $\tilde{X} = (i \mid X)$ and $\tilde{w}' = \left(1, w'\right)$. The 90-percent confidence interval for $\hat{\Delta}$ is calculated by adding and subtracting 1.645 times its standard error to the point estimate.

We do not know w, the acres in the 1991 farm operation, for every farmer in the Bank. But we do know $w' X$. In the case of GWEL contracts, this is the total amount of water bought. In the case of NIL contracts, this is the vector of water sold to the Bank by crop (we assume multiple-response contracts with no pumps available are for rice water).

We predict the impact of NIL contracts separately from GWEL contracts using the estimates in Tables A.1 and A.2.

To calculate how much operating costs fell relative to what they would have been had there been no Bank, we also need to know what 1991 operating costs would have been had there been no Bank for the farmers in the Bank. We calculate this as

$$\begin{aligned} Y^N &= w' \ y^N \\ &= w' \left(y^{90} + \alpha\right) \ , \end{aligned}$$

where y^{90} is an (N × 1) vector of per-acre operating costs in 1990. Unfortunately, we do not know total acres for all farmers in the Bank. We thus use the following approximation:

$$\hat{Y}^N = \left[\sum_s w_s\left(y_s^{90} + \alpha\right) \right] \frac{\text{AF sold to Bank}}{\text{AF in sample}} ,$$

where s indexes the farmers in the Bank. This assumes that operating costs per acre-foot sold to the Bank in 1990 are the same for the farmers in the sample as for farmers who participated in the Bank but are not in the sample. Predictions for NIL contracts are again done separately from GWEL contracts.

In calculating the 90-percent confidence interval for the percentage change in operating costs, we assume that Y^N is known with certainty and simply divide the endpoints of the 90-percent confidence interval of $\hat{\Delta}$ by $\hat{Y}^N$.

Projections for Counties

We use the same methodology to estimate the reduction in operating costs due to the Bank by county. Instead of using acre-feet purchased for the whole Bank, we make separate predictions for each county using the acre-feet purchased by the Bank in that county. To calculate what operating costs would have been in 1991 had there been no Bank (used in calculating the percentage changes in operating costs by county), we multiply our estimate of what operating costs per acre would have been in 1991 without the Bank in our sample times an estimate of acres in agricultural operations by county. To calculate the acres in agricultural operations by county, we start with acreage planted as reported in *California at a Glance*. We then add in the number of acres not planted due to the Bank. Because the farmers in our survey planted 90 percent of the land in their farming operations on average, we divide the sum just calculated by 0.9 to convert acres planted to acres in farm operations.

The acre-feet of water sold to the Bank by county are listed separately for NIL and GWEL contracts in Tables A.3 and A.4. Acre-feet sold to the Bank for NIL contracts are calculated from data provided by DWR on the number of acres fallowed and the water purchased per acre by contract. The amount of water purchased per acre varied depending on location and soil characteristics. In some cases, the amount purchased per acre was missing, so we used the average per acre purchased for the particular crop in other contracts. Because the U.S. Bureau of Reclamation did not give DWR credit for all the water purchased through NIL contracts, the figures for NIL contracts are somewhat higher than the actual amount of water received by DWR.

Table A.3

Acre-Feet Sold to Bank by County for No-Irrigation Contracts

County	Rice	Corn	Sugar Beets	Alfalfa	Pasture	Wheat	Other	Total
Butte	4,886	0	0	0	0	2,717	1,188	8,791
Colusa	8,086	0	285	0	0	0	0	8,371
Contra Costa	0	14,809	0	2,457	5,372	2,505	1,491	26,635
Sacramento	2,892	20,537	4,113	3,613	6,466	22,560	6,874	67,055
San Joaquin	0	56,862	11,492	13,756	2,145	27,402	11,687	123,345
Shasta	2,095	0	0	1,892	11,808	95	88	15,979
Solano	0	12,466	3,747	3,313	11,628	11,070	4,693	46,917
Sutter	9,564	3,620	2,871	0	0	103	862	17,020
Yolo	3,110	26,445	8,401	12,012	19,838	16,136	19,661	105,602
Yuba	0	0	0	0	0	0	0	0
Total	30,633	134,739	30,909	37,043	57,257	82,588	46,544	419,714

Table A.4

Acre-Feet Sold to Bank by County for Groundwater Contracts

			Multiple Response		
County	Groundwater Exchange	Farmer Not Involved	Groundwater Available	Groundwater Not Available	Total
Butte	0	0	62,467	31,233	93,700
Colusa	25,517	12,002	0	0	37,519
Contra Costa	0	2,529	0	0	2,529
Glenn	0	0	2,400	1,200	3,600
Sutter	7,848	0	1,800	900	10,548
Yolo	27,308	1,420	0	0	28,728
Yuba	79,287	2,679	0	0	81,966
Total	139,960	18,630	66,667	33,333	258,590

Impact of the Bank on Farm Investment

Tables A.5 and A.6 report estimates for the impact of the Bank on farm investment for NIL and GWEL contracts, respectively. Predictions for all participants in the Bank and confidence intervals are calculated as described in the section above on predicting the impact of all Bank sales. We asked farmers how much more or less than normal they invested in their farm in 1991. We therefore do not know what they invested in 1990 and cannot calculate the percentage change in operating costs and farm investment from what they would have been in 1991 had there been no Bank.

Table A.5

Regression Analysis for Prediction of Impact of NIL Contracts on Farm Investment

	Coeff.	Std. Error
Constant	11.97	8.51
Rice	–4.85	16.07
Sugar beets	–5.71	7.97
Alfalfa	8.09	6.23
Wheat	9.57	10.61
Corn	0.61	9.74
Other	26.74[a]	9.86
Pasture	9.19[b]	5.59
N	82	
Dep. mean	22.22	
R-square	0.15	
RMSE	32.69	

[a]Significantly different from zero with 95-percent confidence.
[b]Significantly different from zero with 90-percent confidence.

Table A.6

Regression Analysis for Prediction of Impact of GWEL Contracts on Farm Investment

	Coeff.	Std. Error
Constant	36.24	25.56
AF sold per acre	15.55	17.78
N	13	
Dep. mean	55.73	
R-square	0.07	
RMSE	45.07	

B. Statistical Methodology and Calculations for Analysis in Section 3

Characteristics of the Business Survey

Before discussing statistical methodology, we provide some additional information on gross revenues for the firms in the sample. Table B.1 reports the average level of gross revenues in 1990 and 1991 and the number of firms who reported them by firm characteristic.

Table B.1

Average Gross Revenues in 1990 and 1991 by Firm Characteristic

	Number of Firms	1990 ($M)	1991 ($M)
All firms	56	26.67	23.97
1990 gross revenues ($million)			
Less than 1	12	0.53	0.48
1 to 10	23	3.98	3.57
Greater than 10	21	66.46	59.76
Type of business			
Provides farm inputs			
Applicators	7	0.95	0.84
Fuel	7	19.58	18.29
Equipment	11	17.45	14.38
Seed, chemicals, other	13	9.82	8.85
Handles farm output	18	57.23	51.95
Firm location			
In 6 counties most impacted[a]	40	24.60	22.20
Other counties	16	31.80	28.50
Percentage of 1990 sales/purchases in 6 counties most impacted[a]			
35 or less	15	49.60	45.10
36 to 74	14	22.00	20.20
75 or greater	24	6.10	5.30

[a]Butte, Contra Costa, Sacramento, San Joaquin, Yolo, and Yuba.

Methodology for Analyzing Changes in Gross Revenues of Agricultural Businesses

The ordinary least square method is used to estimate the relation between the percentage change in gross revenue between 1990 and 1991 and firm characteristics. The relation is of the form:

$$dpy_j = X_j\beta + \varepsilon_j \ ,$$

where dpy_j is the percentage change in the gross revenues and X_j is a categorical variable that takes on the value one if the firm characteristic falls in the named category and zero otherwise. ε_j is distributed i.i.d. normal with variance σ^2.

Estimates are presented in Table B.2. Because several firms did not provide information on change in gross revenues or the percentage of purchases and sales by county, the regression is based on only 56 observations. The coefficients are estimated with a great deal of uncertainty, and none are significantly different from zero with 10-percent confidence. As indicated by the low

Table B.2

Regression of Percentage Change in Gross Revenue Between 1990 and 1991 on Firm Characteristics

	Coefficient	Standard Error
Constant	–11.65	8.68
1990 gross revenues ($M)		
Less than 1	(reference)	
1 to 10	2.05	6.20
Greater than 10	1.11	7.41
Type of business		
Applicators	0.81	8.63
Fuel	6.63	9.65
Equipment	(reference)	
Seed, chemicals, other	–0.58	7.00
Handles farm output[a]	2.63	6.83
Percentage of sales/purchases in 6 counties most impacted[a]		
Less than 35	(reference)	
36 to 74	–1.47	6.26
75 or greater	–2.33	5.59
N	56	
Dep. mean	–10.30	
R-square	0.02	
RMSE	16.76	

[a]Butte, Contra Costa, Sacramento, San Joaquin, Yolo, and Yuba.

R-square, the regression explains only a small percentage of the variation in the percentage change in gross revenues across firms. This indicates that many factors other than those explicitly considered here affect gross revenues.

We use the properties of linear models to estimate the differences in the percentage change in gross revenues between firms with different characteristics, as well as to estimate the standard errors of the differences. Let X be the data matrix used to estimate the equation. Let $\tilde{X}$ be a matrix in which each row contains the firm characteristics for a desired prediction. For example, the first row of $\tilde{X}$ contains the values of the variables for the reference prediction and subsequent rows contain values for the other desired predictions. Finally, let $\hat{\beta}$ be the vector of estimated coefficient and w be a matrix that takes differences between the reference and other predictions. The differences between the reference and the predictions are then given by $w \tilde{X} \hat{\beta}$, and the covariance matrix is

$$\sigma^2 w \tilde{X}(X'X)^{-1}\tilde{X}'w' \ .$$

Calculation of Estimated Negative Impact of Bank on Overall Farm Economy

As a first approximation of the negative impact of the Bank relative to the entire farm economy, we multiply the estimated drop in agriculturally related personal income by the proportion of county income generated by agriculture. The first column of Table B.3 contains the percentage of overall county personal income that is agriculturally related. This is determined by taking the ratio of earnings on the farm and in the agricultural services, food, and kindred products industries to total personal income by place of work (Bureau of Economic Analysis, 1992). We assume that the personal income in the farm sector fell by the same percentage as the average percentage change in farm operating costs and crop revenues for each county. Our estimates of the percentage decline in agriculturally related personal income are reported in the second column of Table B.3. The last contains the product of the first two and is our estimate of the overall drop in county personal income caused by the negative impacts of the Bank. The reader should note that these estimates do not include multiplier effects.

Table B.3

Approximate Magnitude of Negative Impacts of Bank on Overall County Economy

County	Percentage of Income from Agriculture	Impact of the Bank on Agricultural Businesses (percent)	Negative Impact of Bank on Personal Income (percent)
Butte	8	–5	–0.4
Colusa	71	–1	–0.7
Contra Costa	1	–5	–0.1
Glenn	42	–0.2	0
Sacramento	2	–4	–0.1
San Joaquin	13	–3	–0.4
Shasta	2	–2	<–0.1
Solano	5	–2	–0.1
Stanislaus	22	0	0
Sutter	24	–1	–0.2
Tehama	20	0	0
Yolo	10	–5	–0.5
Yuba	8	–3	–0.3

C. Economic Data on Selling Counties

Table C.1 presents changes in measures of economic activity between 1990 and 1991 in counties selling water to the Bank. We used data provided by the state Department of Finance to calculate changes in population between 1990 and 1991. There is considerable variance in the rates of change across counties. Changes in employment, unemployment, and agricultural employment by county were calculated from data provided by the California Employment Development Department. The percentage growth in county welfare payments between 1990 and 1991 was calculated using data from the state Health and Welfare Agency.

In most of the counties, population grew much faster than employment, and agriculture employment dropped much more than overall employment. In fact, between 1983 and 1991, population outpaced employment growth in almost all counties selling water to the Bank. This partially explains why the percentage growth in unemployment is much larger than the decrease in agricultural employment. The recession and the movement of companies out of California are other possible explanation for the dramatic growth in county unemployment.

In Appendix B, we provide a measure of the impact of the Bank on agricultural businesses (see Table B.3). Here, we compare this with the percentage of the

Table C.1

Change in Measures of County Economic Activity Between 1990 and 1991 (percent change)

County	Population	Personal Income	Employ-ment	Unemploy-ment	Agricultural Employment	Welfare Payments
Butte	3	<1	2	30	–2	5
Colusa	2	3	4	39	–9	6
Contra Costa	2	<1	–1	31	–8	8
Glenn	2	–1	1	29	–10	8
Sacramento	3	2	1	40	0	9
San Joaquin	3	1	1	27	–2	5
Shasta	4	2	4	29	–6	3
Solano	4	2	1	28	–5	10
Stanislaus	3	<1	<1	28	<–1	8
Sutter	4	5	–2	33	–4	7
Tehama	4	2	1	16	–2	13
Yolo	3	<–1	1	26	–9	10
Yuba	3	3	–2	41	–3	7

acreage usually planted that was not irrigated by the Bank. Table C.2 first reproduces the estimate we developed in Appendix B and then the percentage of acreage not irrigated. The percentage of acreage not irrigated is the ratio of acres in fallowing contracts as reported by DWR and acreage planted in 1990 as reported by *California Farmer* magazine.[1] Note that these two measures will not be perfectly correlated because the percentage of acreage not irrigated does not consider what type of crop was not irrigated or the impacts of groundwater contracts. We know both these factors have an important effect on the overall impact.

Table C.2

Impact of Bank on Agricultural Businesses and Percentage of County Agricultural Land Not Irrigated

County	Percent Drop in Agricultural Businesses Due to Bank	Percent of Acres Not Irrigated
Butte	–5	14
Colusa	–1	1
Contra Costa	–5	29
Glenn	0	0
Sacramento	–4	17
San Joaquin	–3	10
Shasta	–2	6
Solano	–2	8
Stanislaus	0	<1
Sutter	–1	2
Tehama	0	1
Yolo	–5	11
Yuba	–2	0

[1] *California Farmer* compiles crop information reported by county agricultural commissioners (*California Farmer*, 1991).

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